N90-18975

DIFFERENTIAL ELASTIC SCATTERING CROSS SECTIONS FOR 54.9eV POSITRONS INCIDENT ON HELIUM*

R. L. Chaplin, L. M. Diana, D. L. Brooks

The University of Texas at Arlington
Center for Positron Studies
Department of Physics
Arlington, TX, U.S.A.

ABSTRACT

We present absolute differential elastic scattering cross sections measured with our 3-m, high-resolution, time-of-flight spectrometer for 54.9eV positrons incident on He. Five point moving average differential cross sections are plotted against average scattering angles which range from 14° to 36°. Also the averages of five differential cross sections which have adjacent values of scattering angle are plotted versus the corresponding averages of the scattering angles. The curve fitted to these data is shaped like the theoretical curve but has its minimum and its maximum at scattering angles that are about 4° higher and 15° lower respectively than predicted by theory.

INTRODUCTION

The first measurements of differential elastic scattering cross sections for positrons were made in this laboratory on Ar (Ref. 1) with a 25cm spectrometer. Recently, relative values of differential elastic scattering cross sections, I(θ), for Ar obtained with crossed-beam apparatuses, have been reported.[2-4] The 3m time-of-flight (TOF) spectrometer with flight path 12 times that of the instrument that yielded the first I(θ) features vastly improved resolution. We present here preliminary values for I(θ) for 54.9eV positrons incident on He.

The 3m TOF spectrometer and its principles of operation are described in Ref. 5 and the calculation of I(θ) in Ref. 1.

RESULTS AND DISCUSSION

Two figures are used to present the results. In each of these the curve of short dashes is a polynomial fit to experimental data, and the curve of long dashes connects the I(θ) calculated by McEachran and Stauffer.[6]

The averages of five differential cross sections which occur at adjacent values of scattering angle are plotted against the corresponding averages of the scattering angles in Fig. 1. The polynomial fit to these points is shaped generally like the theoretical curve, but the minimum of the fit appears at a scattering angle that is larger by 4° and the secondary maximum at an angle that is 15° smaller than given by theory. Additionally, the experimental I(θ) are considerably larger than the theoretical values.

The five point moving averages of I(θ) plotted in Fig. 2 display two secondary maxima which are smoothed into one by the polynomial fit. It is possible that the apparent double secondary hump results from the superposition of scattering events in the foreward and

*It is a pleasure to note the important past and continuing contributions of Dr. P. G. Coleman.

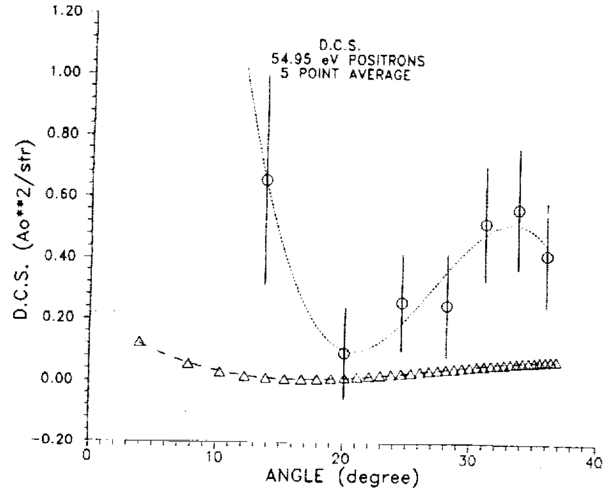

Fig. 1. Five point average differential elastic scattering cross sections. See text for explanations of curves.

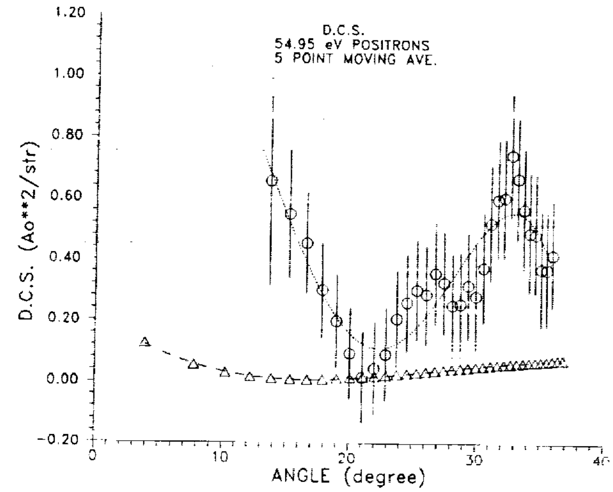

Fig. 2. Five point moving average differential elastic scattering cross sections. See text for explanation of curves.

backward directions, for back-scattered positions are reflected by the moderator and then appear in the TOF spectrum like positrons scattered into the forward supplementary angles with slightly longer flight paths. We will check this possibility by repeating the experiment with an appreciable spatial separation of moderator and scattering chamber to effect a significant relative shift of peaks on the TOF spectrum from forward and backward scattering events.

The TOF spectra for 54.9eV positrons yield $(0.47 \pm 0.04)\pi a_0^2$ for total cross section for impact ionization, Q_{ion}, $(0.083 \pm 0.011)\pi a_0^2$ for total excitation cross section, Q_{ex}, and $(0.16 \pm 0.06)\pi a_0^2$ for total elastic scattering cross section, Q_{el}. The Q_{ion} and Q_{ex} will be reduced slightly and the Q_{el} increased somewhat by application of corrections for double scattering. Even after correction for double scattering, the Q_{ion} will agree with the result obtained with our 2.3m spectrometer,[7] the Q_{ex} with the value of $0.079\pi a_0^2$ read from Sueoka's plot[8], and the Q_{el} will be reasonable, probably about $0.2\pi a_0^2$. However, the data in Ref. 7 suggest the possibility that Q_{el} at 54.9eV could be as high as $0.3\pi a_0^2$. This is one reason why our subsequent data acquisitions at 54.9eV will be made with stronger magnetic fields. The 145G used in obtaining the results reported here was ideal for the resolution of the excitation TOF peak from elastic scattering events but was too low to insure maximum possible detection of positrons scattered elastically between 36° and 144°. We estimate that 0.25% of the elastic events at 36° but that none at any of the other angles for which I(θ) are reported were lost in achieving elastic-excitation resolution.

ACKNOWLEDGMENTS

We wish to thank J. M. Wadehra for sharing the results of his Born approximation calculations of Q_{el} with us and R. P. McEachran and A. D. Stauffer for their polarized orbital results for Q_{el}. We wish to acknowledge, also, the support of the National Science Foundation through Grant PHY-8506933.

REFERENCES

1. P. G. Coleman and J. D. McNutt, Phys. Rev. Lett. 42, 1130 (1979).
2. G. M. A. Hyder, M. S. Dababneh, Y-F Hsieh, W. E. Kauppila, C. K. Kwan, M. Mahdavi-Hezaveh, and T. S. Stein, Phys. Rev. Lett. 57, 2252 (1986).
3. W. E. Kauppila and T. S. Stein, in Atomic Physics with Positrons, Proceedings of NATO Advanced Research Workshop on Atomic Physics with Positrons, London, England, edited

J. W. Humberston and E. A. G. Armour (Plenum Press, New York and London, 1987), p. 27.

4. K. Floeder, P. Honer, W. Raith, A. Schwab, G. Sinapius, and G. Spicher, Phys. Rev. Lett. 23, 2363 (1988).
5. L. M. Diana, R. L. Chaplin, D. L. Brooks, P. G. Coleman, and J. P. Howell, in Positron Annihilation, Proceedings of the Eighth International Conference on Positron Annihilation, Gent, Belgium, edited by L. Dorikens-Vanpraet, M. Dorikens, and D. Segers (World Scientific, Singapore, 1989), p. 308.
6. R. P. McEachran and A. D. Stauffer, in Proceedings of the Third International Workshop on Positron (Electron)-Gas Scattering, Detroit, Michigan, edited by W. E. Kauppila, T. S. Stein, and J. M. Wadehra (World Scientific, Singapore, 1986), p. 122 and personal communication.
7. L. M. Diana, R. L. Chaplin, D. L. Brooks, J. T. Adams, L. K. Reyna, and P. G. Coleman, contributed article in these proceedings.
8. O. Sueoka, J. Phys. Jpn. 51, 3757 (1982).